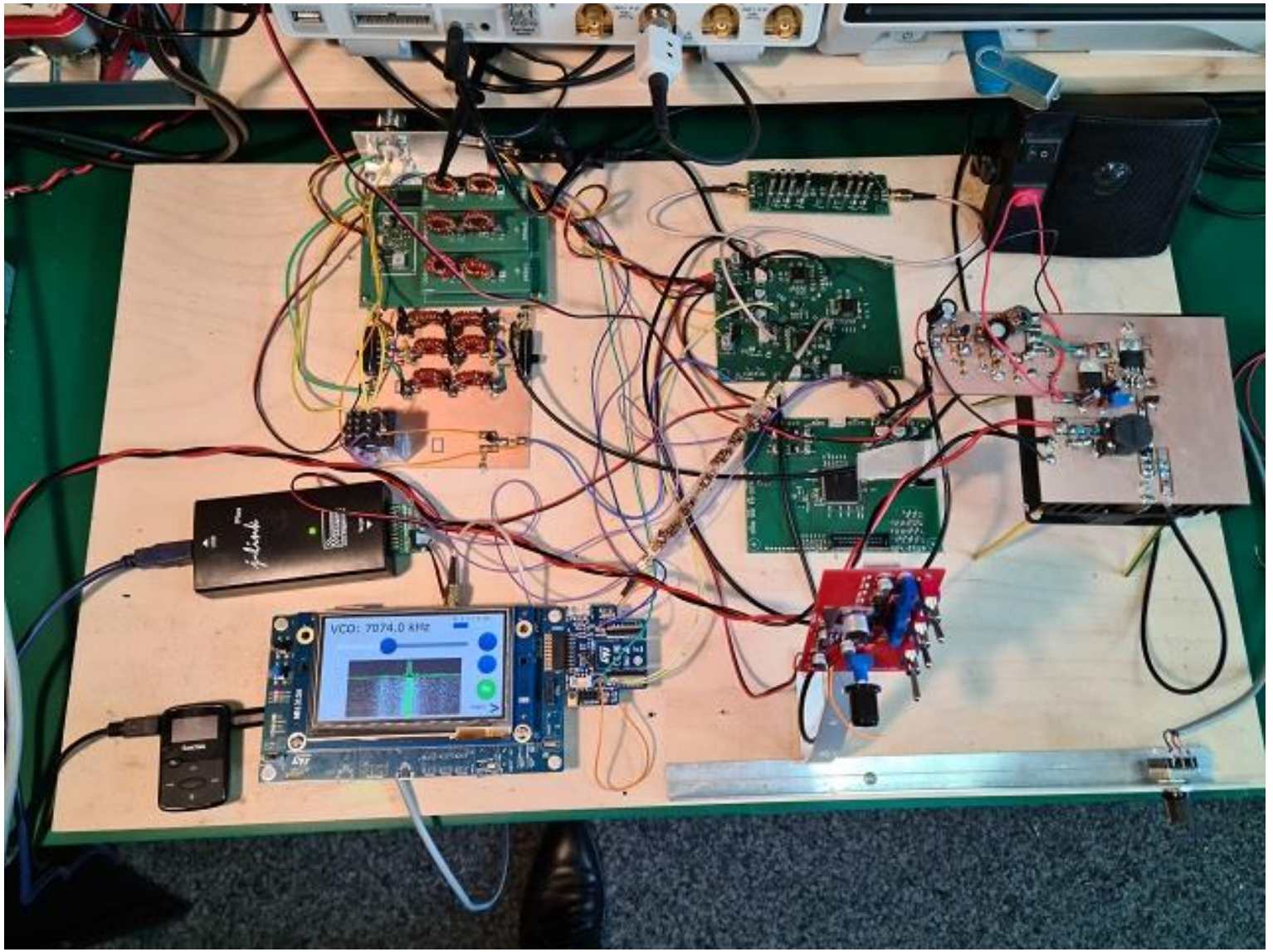
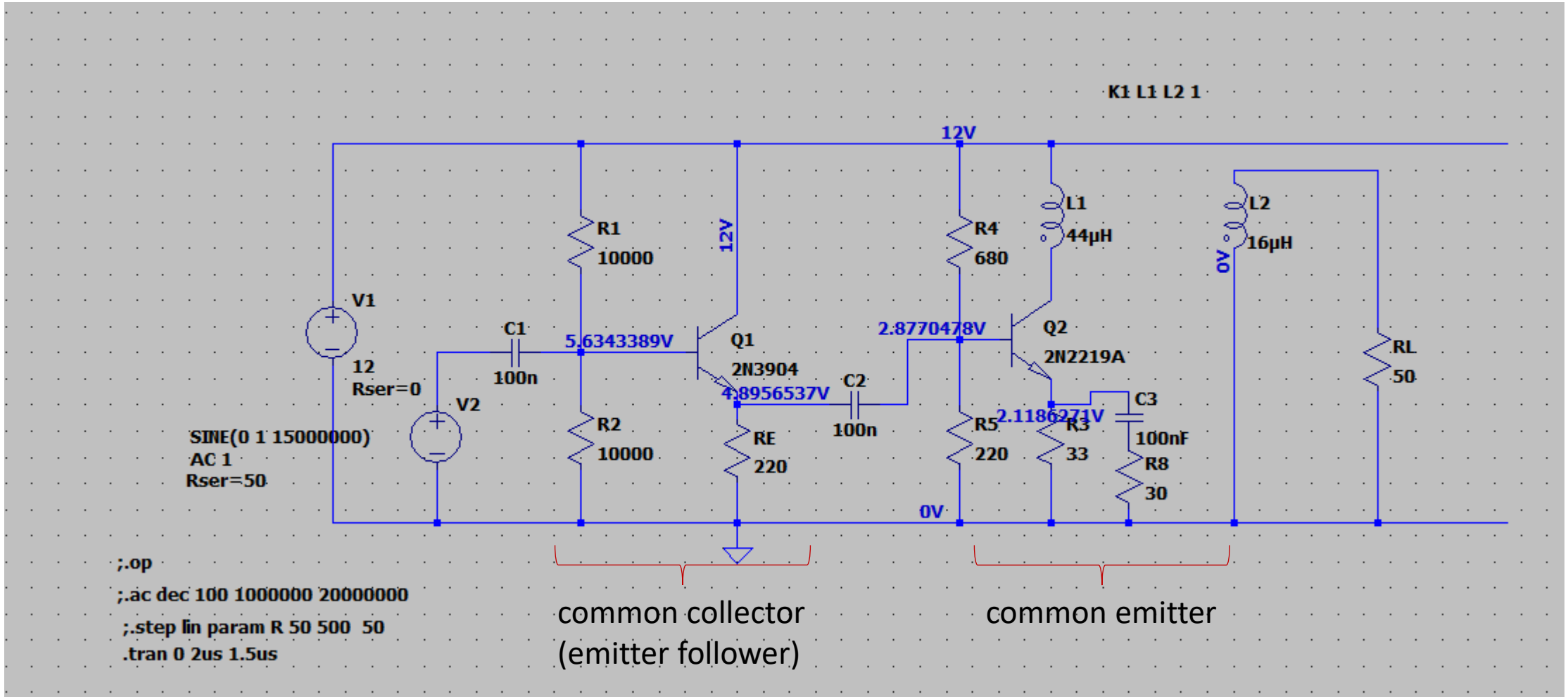
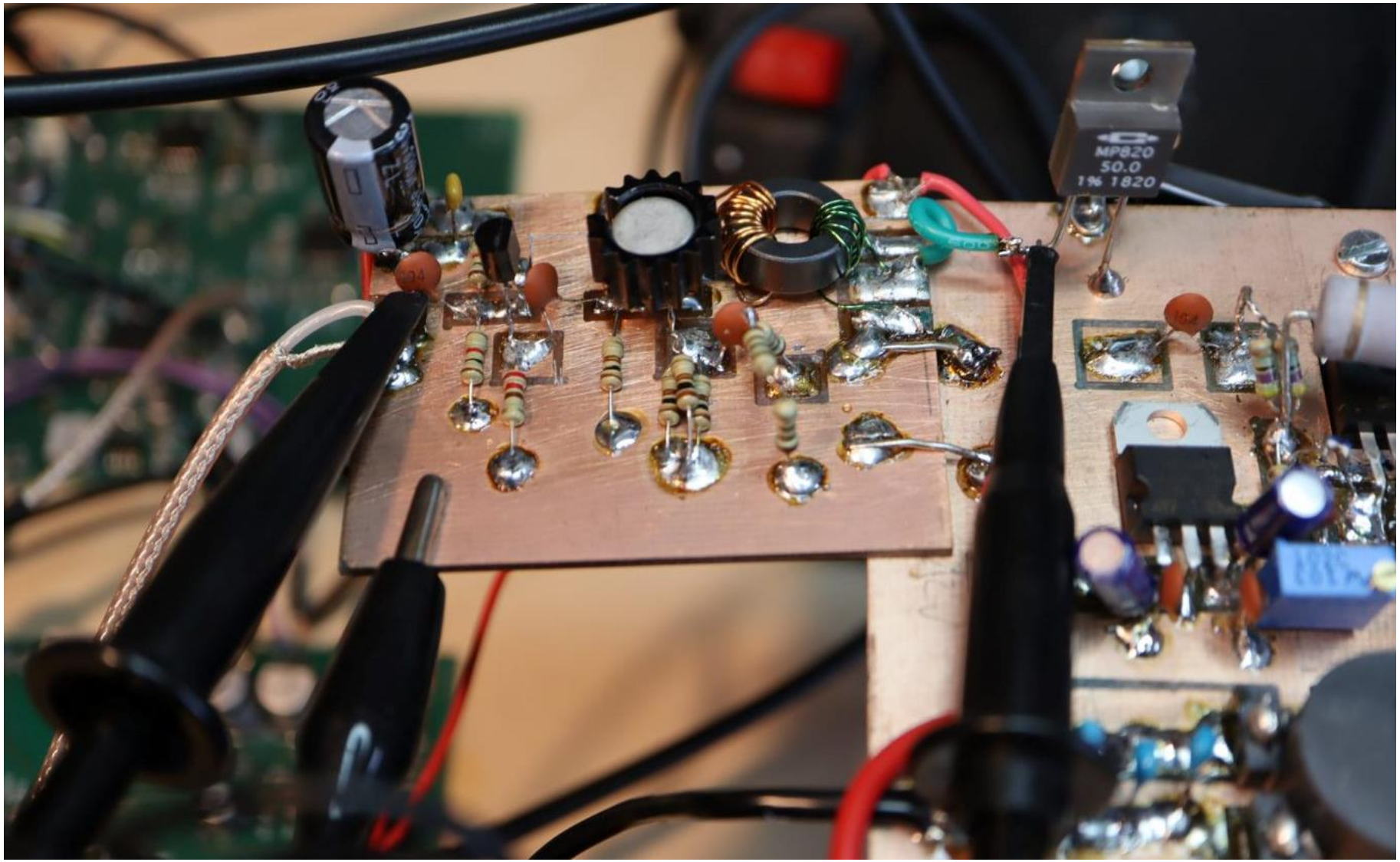
Design Power-Preamplifier



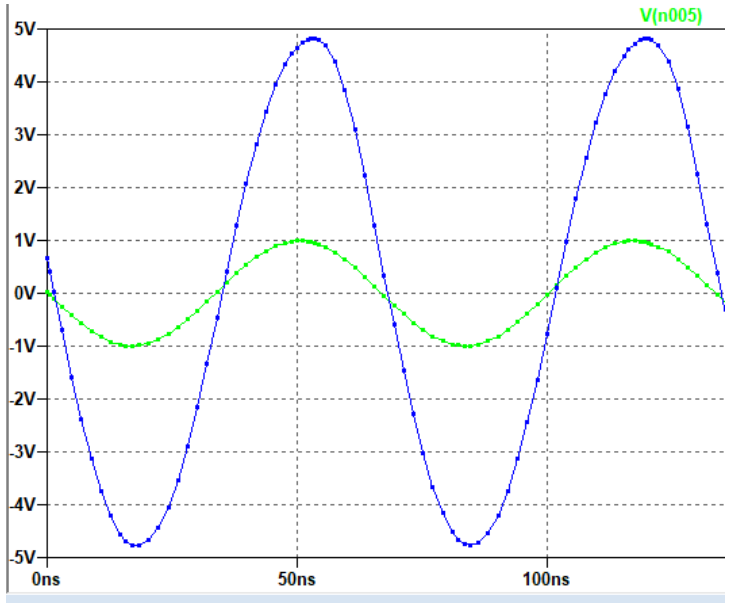
Pre-Amplifier Design



Pre-Amplifier Circuit

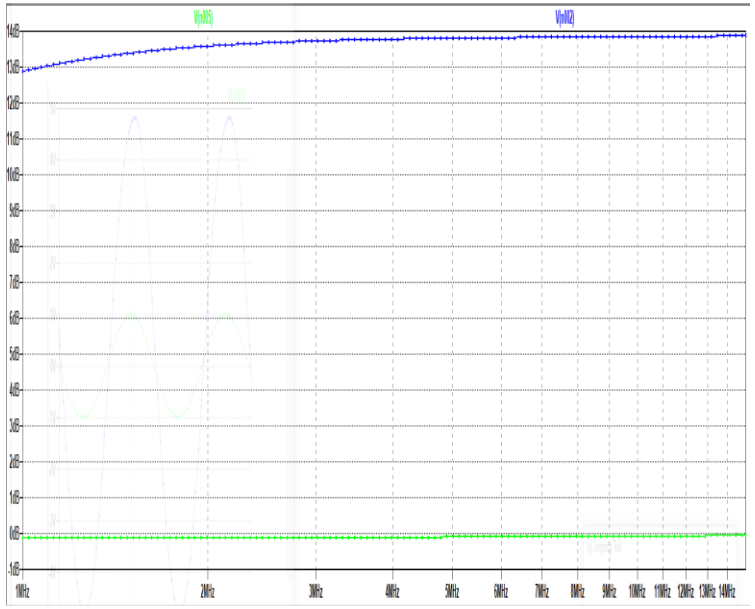


Pre-Amplifier Design

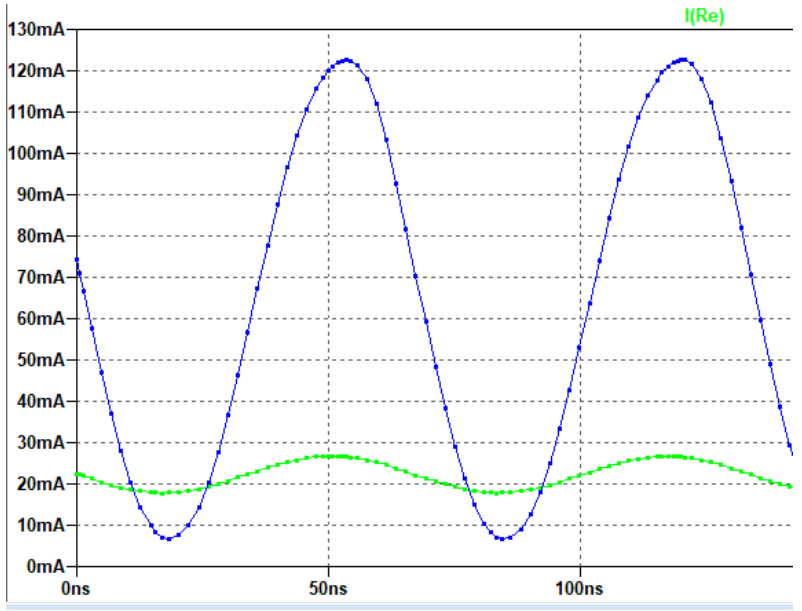


Vin = 2Vpp @15MHz
Vout = 9.6Vpp
Av = 14dB

green = Vin, blue = Vout



Vin = 0.3V @1 - 20MHz
1V = 0dB, 0.3V = -10.45dB
Av = 13.5dB



Point of operation:
Ie 2N3904: 24mA
Ic 2N2219: 64mA
@10V → 0.7W

Difference between CB, CE, CC BJT transistor configurations

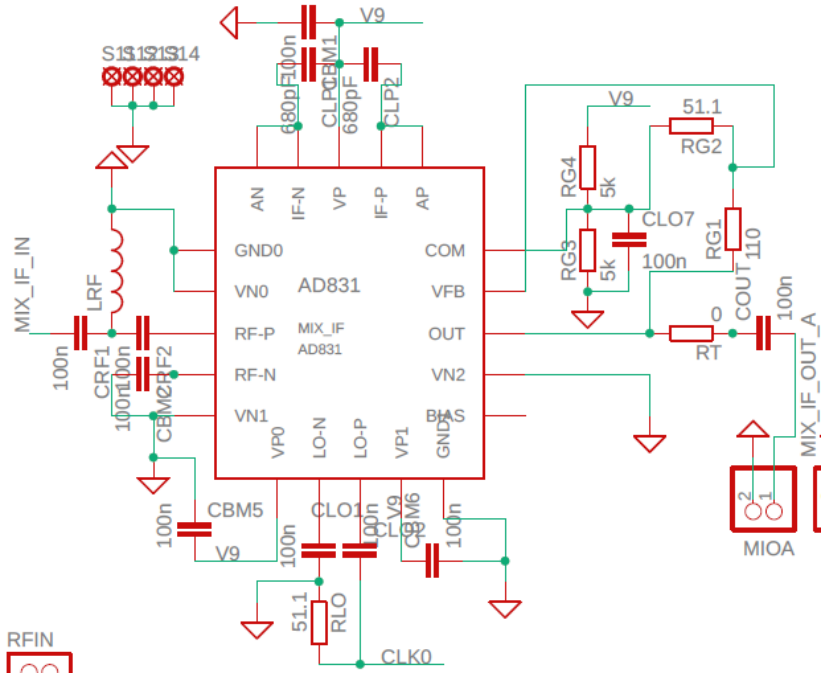
BJT is a voltage dependent current-source → can be used as an amplifier

Parameter	Common Base	Common Emitter	Common Collector
Voltage Gain	High, Same as CE	High	Less than Unity
Current Gain	Less than Unity	High	High
Power Gain	Moderate	High	Moderate
Phase inversion	No	Yes	No
Input Impedance	Low (50 Ohm)	Moderate (1 KOhm)	High (300 KOhm)
Output Impedance	High (1 M Ohm)	Moderate (50 K)	Low (300 Ohm)

https://www.rfwireless-world.com/Terminology/CB-vs-CE-vs-CC-transistor-configurations.html

https://www.tutorialspoint.com/amplifiers/amplifiers_based_on_configurations.htm

Output Impedance of mixer AD831

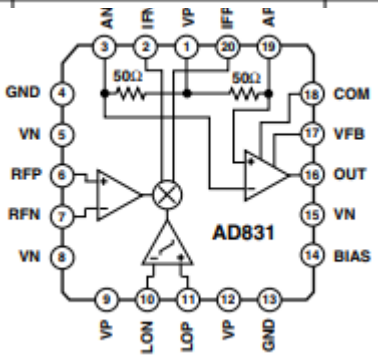


IF OUTPUT				
Bandwidth	Single-Ended Voltage Output, –3 dB		200	MHz
	Level = 0 dBm, R_L = 100 Ω			
Conversion Gain	Terminals OUT and VFB Connected		0	dB
Output Offset Voltage	DC Measurement; LO Input Switched ±1	–40	+15	+40 mV
Slew Rate			300	V/μs
Output Voltage Swing	R_L = 100 Ω, Unity Gain		±1.4	V
Short Circuit Current			75	mA

Using the Output Amplifier

The AD831's output amplifier converts the mixer core's differential current output into a single-ended voltage and provides an output as high as ±1 V peak into a 50 V load (+10 dBm). For unity gain operation (Figure 5), the inputs AN and AP connect to the open-collector outputs of the mixer's core and OUT connects to VFB.

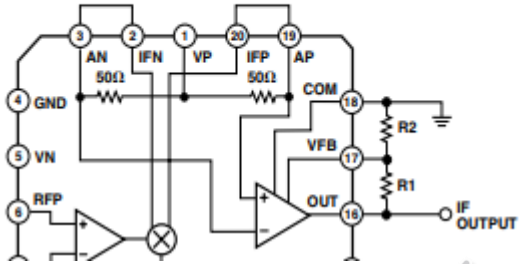
Ω!



$$G_{dB} = 20 \log_{10}\left(\frac{R1+R2}{R2}\right)$$

Ideal OpAmps: infinite input impedance, zero output impedance

Closed-loop output impedance or open loop output impedance, both designated by Zo. Zo is defined as the small signal impedance between the output terminal and ground. Data sheet values run from 50Ω to 200Ω.



Design of the 2N3904 common collector stage

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 60134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter	–	60	V
V_{CEO}	collector-emitter voltage	open base	–	40	V
V_{EBO}	emitter-base voltage	open collector	–	6	V
I_C	collector current (DC)		–	200	mA
I_{CM}	peak collector current		–	300	mA
I_{BM}	peak base current		–	100	mA
P_{tot}	total power dissipation	$T_{amb} \leq 25$ °C; note 1	–	500	mW
T_{stg}	storage temperature		−65	+150	°C
T_j	junction temperature		–	150	°C
T_{amb}	ambient temperature		−65	+150	°C

CHARACTERISTICS

T_{amb} = 25 °C.

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
I_{CBO}	collector-base cut-off current	V_{CB} = 30 V; I_E = 0 A	–	50	nA
I_{EBO}	emitter-base cut-off current	V_{EB} = 6 V; I_C = 0 A	–	50	nA
h_{FE}	DC current gain	V_{CE} = 1 V; note 1			
		I_C = 0.1 mA	60	–	
		I_C = 1 mA	80	–	
		I_C = 10 mA	100	300	
		I_C = 50 mA	60	–	
		I_C = 100 mA	30	–	
V_{CEsat}	collector-emitter saturation voltage	I_C = 10 mA; I_B = 1 mA; note 1	–	200	mV
		I_C = 50 mA; I_B = 5 mA; note 1	–	200	mV
V_{BEsat}	base-emitter saturation voltage	I_C = 10 mA; I_B = 1 mA; note 1	–	850	mV
		I_C = 50 mA; I_B = 5 mA; note 1	–	950	mV
C_c	collector capacitance	V_{CB} = 5 V; $I_E = i_e$ = 0 A; f = 1 MHz	–	4	pF
C_e	emitter capacitance	V_{EB} = 500 mV; $I_C = i_c$ = 0 A; f = 1 MHz	–	8	pF
f_T	transition frequency	V_{CE} = 20 V; I_C = 10 mA; f = 100 MHz	300	–	MHz
F	noise figure	V_{CE} = 5 V; I_C = 100 ∝A; R_S = 1 kΩ; f = 10 Hz to 15.7 kHz	–	5	dB

Selected:

CC input impedance >> 50 Ω → impedance

Ic = 20mA

set Vout in the middle of Vdd ~6V

V_{BE} = 0.7V

$R_E = \frac{6V - 0.7V}{20mA}$ = 265 Ω → 220 Ω selected

Design of the 2N2219 common emitter amplifier

Switching and Linear Application DC and VHF Amplifier Applications

ABSOLUTE MAXIMUM RATINGS (Ta=25°C unless specified otherwise)

DESCRIPTION	SYMBOL	2N2218, 19	UNIT
Collector Emitter Voltage	V_{CEO}	30	V
Collector Base Voltage	V_{CBO}	60	V
Emitter Base Voltage	V_{EBO}	5	V
Collector Current Continuous	I_C	800	mA
Power Dissipation @Ta=25°C	P_D	800	mW
Derate Above 25°C		4.57	mW/°C
Power Dissipation @ Tc=25°C	P_D	3	W
Derate Above 25°C		17.1	mW/°C
Operating and Storage Junction Temperature Range	T_j, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C unless specified otherwise)

DESCRIPTION	SYMBOL	TEST CONDITION	2N2218		2N2219		UNIT
			MIN	MAX	MIN	MAX	
DC Current Gain	h_{FE}	I_C=0.1mA,V_{CE}=10V*	20		35		
		I_C=1mA,V_{CE}=10V	25		50		
		I_C=10mA,V_{CE}=10V*	35		75		
		I_C=150mA,V_{CE}=1V*	20		50		
		I_C=150mA,V_{CE}=1V*	40	120	100	300	
		I_C=500mA,V_{CE}=10V*	20		30		
DYNAMIC CHARACTERISTICS							
Transition Frequency	f_T	I_C=20mA, V_{CE}=20V f=100MHz	250		250		MHz
Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0 f=100KHz		8		8	pF
Input Capacitance	C_{ib}	V_{EB}=0.5V, I_C=0 f=100kHz		30		30	pF

Selected:

I_C = 60mA
choose a R_E to have negative current feedback for temp. stabilization
allow max. voltage swing on the inductance
Go for 2V on R_E

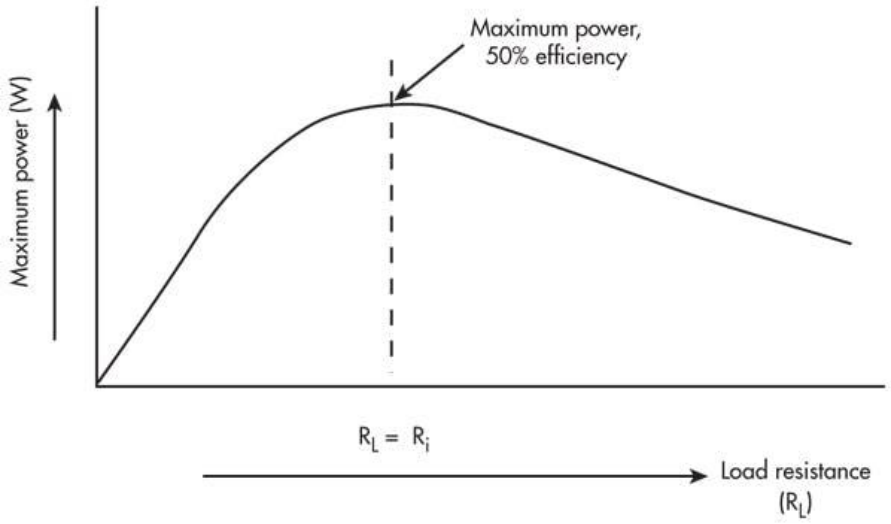
$\frac{2V}{60mA}$ = 33 Ω → 3x 100 Ω in parallel

V_{BE} = 0.7V

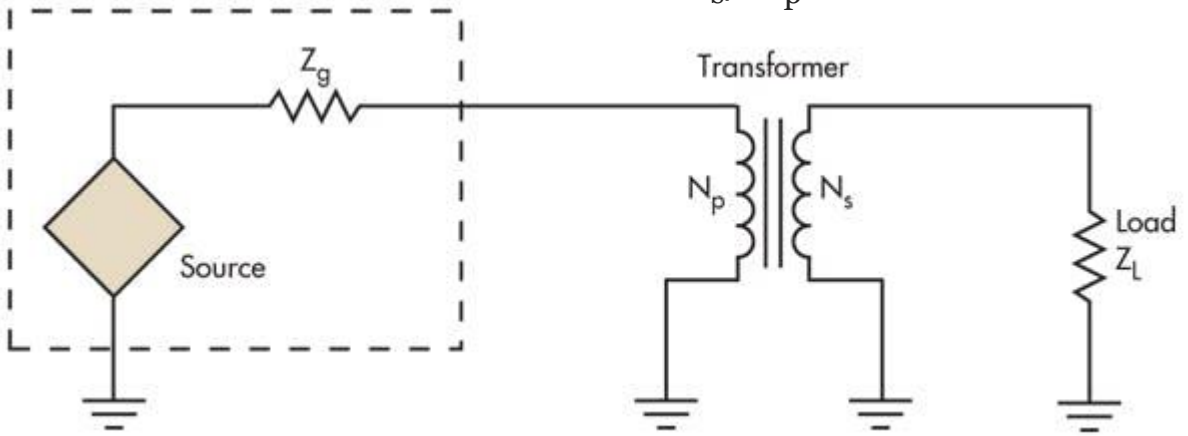
$\frac{2V+0.7V}{12mA}$ = 220 Ω

Impedance Matching

Output impedance = input impedance = max. power transfer, lowest amout of reflections



$N = N_s/N_p$ = turns ratio



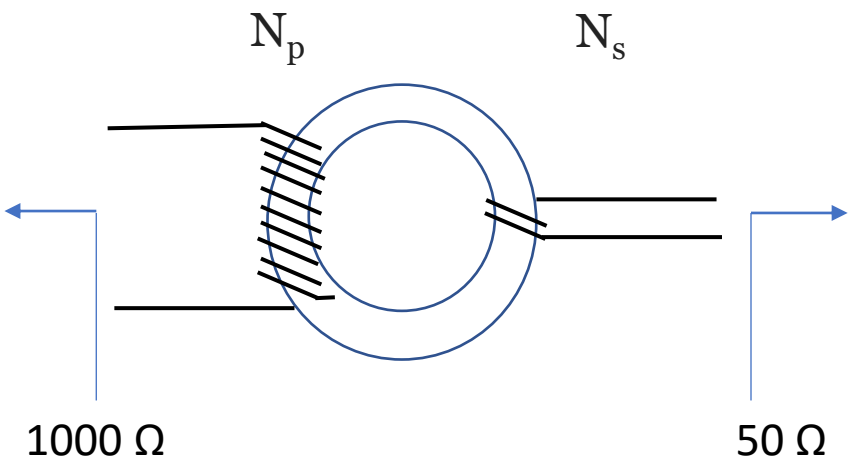
https://www.electronicdesign.com/

Impedance Matching

$P_p = P_s$

$N = N_s/N_p$ = turns ratio

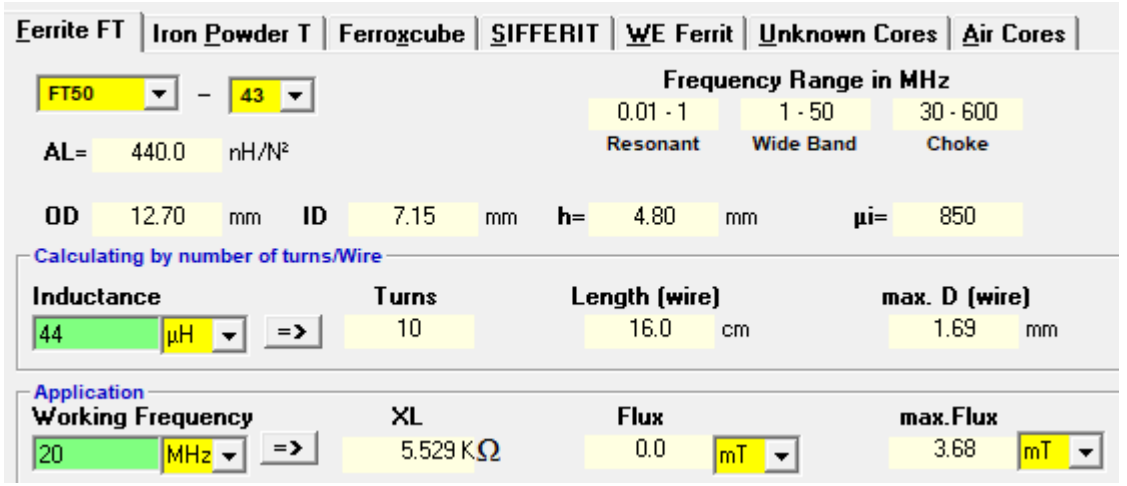
$$\frac{Zs}{Zp} = \left(\frac{Ns}{Np}\right)^2 \longrightarrow \frac{Ns}{Np} = \sqrt{\frac{Zs}{Zp}}$$



$N = 1 : 5$

$$0.22 = \sqrt{\frac{50}{1000}}$$

Ns = 0.22 Np; Np = 10 turns ⟶ Ns = 2 turns



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